

NIAW 4028 (Phule Anurag): A new blast resistant bread wheat variety for restricted irrigation conditions of Peninsular India

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Wheat holds a significant position in India's agricultural landscape, serving as one of the country's major staple crops and a key component of its food security strategy. Having a significant share in consumption of food basket with a 36% share in the total food grains produced from India, wheat is extensively procured by the government and distributed to a majority of the population; it ensures not only food security but also nutrition security. (Sendhil *et al.*, 2019). Cultivated across diverse agro-climatic regions, wheat production in India has witnessed steady growth over the years, propelled by advancements in agricultural technology, improved farming practices, and government support. India is the second in wheat production after China on the globe. During 2022, India produced 107.7 million tonnes of wheat with an average productivity of 35.37 q ha⁻¹.

The Peninsular Zone of India encompasses a vast expanse of diverse agro-climatic conditions, ranging from semi-arid to humid regions, spanning states such as Maharashtra, Karnataka, Andhra Pradesh, and Tamil Nadu. This zone is characterized by its unique challenges for agriculture, including erratic rainfall patterns and limited water availability, making it crucial to cultivate crops that exhibit resilience to drought and environmental stressors. Wheat cultivation in the Peninsular Zone faces additional hurdles, notably the prevalence of rust disease, a fungal infection that can decimate yields if left unchecked. In the ongoing quest to enhance agricultural resilience and

productivity, the development of crop varieties resistant to environmental stresses is paramount. This research article introduces NIAW 4028, a newly released blast-resistant wheat variety specifically bred for the Peninsular Zone of India. Tailored for performance under restricted irrigation conditions, NIAW 4028 represents a significant advancement in sustainable agriculture, addressing both disease resistance and water scarcity challenges. This study details the breeding process, agronomic performance, and potential impact of NIAW 4028, highlighting its role in securing food production in regions prone to blast disease and limited water resources.

NIAW 4028 is a selection from 49th International Bread Wheat Screening Nursery received from CIMMYT, Mexico, during crop season 2016-17 having pedigree WHEAR/SOKOLL/3/TRCH/SRTU//KACHU. During 2017-18 and 2018-19, this entry was evaluated in station trials at Agricultural Research Station, MPKV; Niphad. Further it was evaluated in Preliminary yield trial at four different locations of MPKV, Rahuri University jurisdiction during 2019-20. During the same year; it was tested in Indian Plant Pathology Screening Nursery for screening against stem and leaf rust. Figure 1 depicts flow chart of details of development and evaluation of NIAW 4028. During 2020-21, it was evaluated in National Initial Varietal Trial- 5B (NIVT) under the All India Coordinated Research Project as NIAW 4028 at seven locations in simple lattice design with plot size (7.2 m²) under restricted



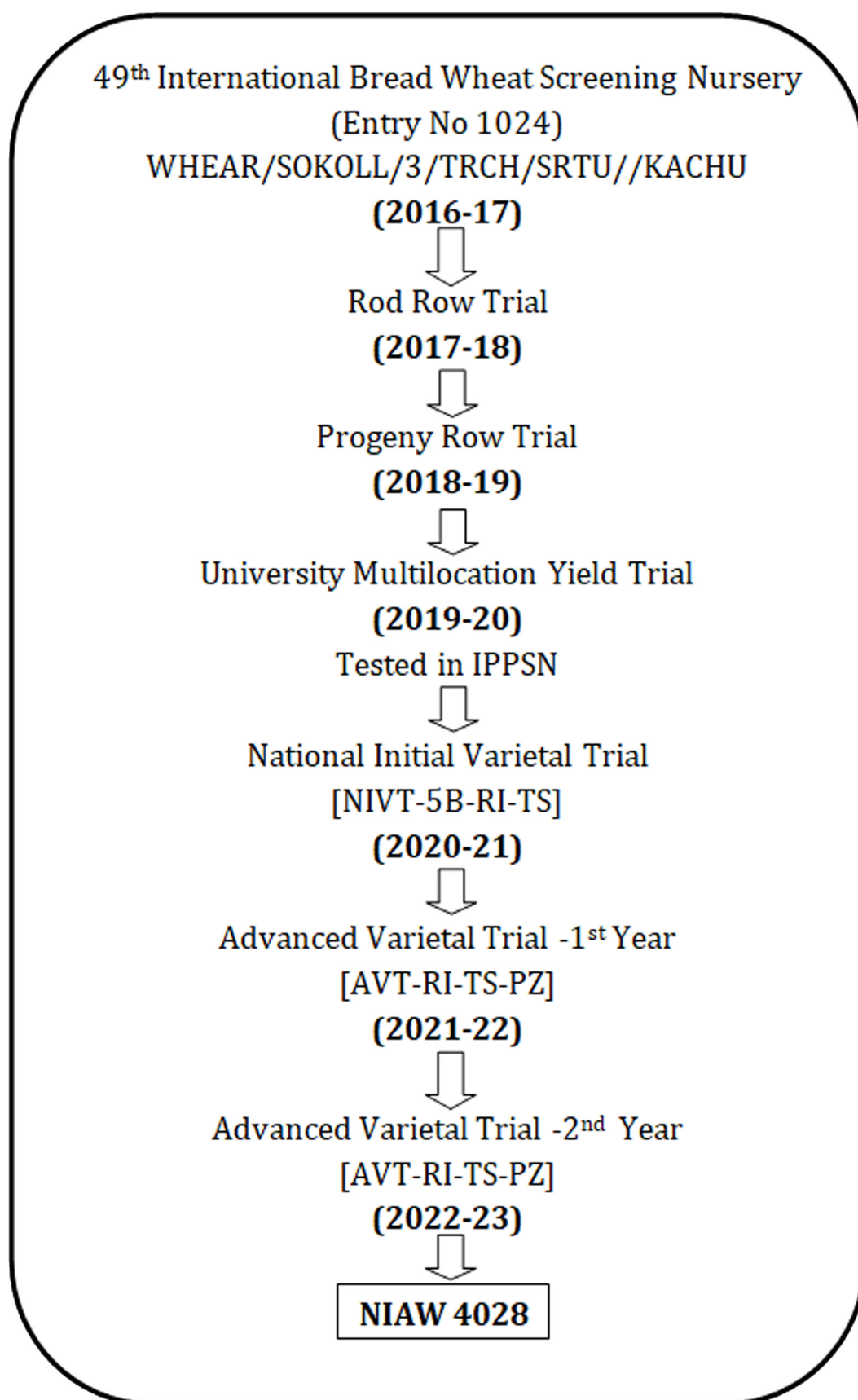


Fig 1: Flow chart showing details of the development of bread wheat variety NIAW 4028



irrigation conditions against checks HI 1605 and DBW 110. During 2021-22 and 2022-23, the genotype was evaluated at 10 and 07 locations, respectively, for yield and yield attributes in Advance Varietal Trials (AVTs) in randomized block design with four replications and plot sizes of 14.4 m² against three checks (HI 1605, MP 1358 and NIAW 3170). NIAW 4028 and the check varieties were screened for stem and leaf rust throughout the yield evaluation process under artificial conditions. Rust severity and response in the field was scored following Loegering (1959) 0-100 scale. For statistical analysis the rust reactions were converted into a coefficient of infection (COI) as used by Loegering (1959). Gene postulation for rust resistance genes was done after multipathotype testing at seedling stage scoring 0-4 scale of Stakman (Stakman *et al.* 1962). The average coefficient of infection (ACI) for both the rusts was calculated following (Saari and Wilcoxson 1974) by multiplying disease severity and constant values of infection type. The constant values for infection types were used based on the following: R = 0.2, MR = 0.4, M = 0.6, MS = 0.8 and S = 1.0. The seedling resistance test for gene postulation using pathotype matching techniques against 21 races of stem rust and 23 races of leaf rust was carried out. During 2020-21 and 2021-22,

the genotype was screened against wheat blast disease at Jashore, Bangladesh at two different sowing dates. Quality attributes such as grain appearance score, hectoliter weight, protein%, sedimentation value, grain hardness, Chapati quality, bread loaf volume, bread quality, biscuit spread factor, wet and dry gluten %, gluten index, Fe and Zn content, and high molecular weight subunits were determined as per standard procedures and protocols. Characterization for Distinctness, Uniformity and Stability of the genotype was carried out as per standard varietal identification procedures in wheat (Gupta *et al.*, 2017).

Yield evaluation in AICWIP trials:

The genotype NIAW 4028 was evaluated for yield in NIVT and AVT for 2020-21, 2021-22 and 2022-23 which resulted in superior and stable performance under timely sown restricted irrigation conditions in Peninsular Zone. The mean performance of NIAW 4028 in coordinated trials over the course of three years in comparisons to the check varieties is presented in Table 1. NIAW 4028 recorded highest yield potential of 46.8 q ha⁻¹ (in AVT I) with an average yield of 33.43 q ha⁻¹ under restricted irrigation condition. NIAW 4028 was more likely to be appear in first non-significant group (15/24) than check varieties NIAW 3170 (11/17) and HI 1605 (12/24).

Table 1: Yield Performance of NIAW 4028 in AICRP Yield Trials (2020-21 to 2022-23)

Item	Year of testing	No. of trials	NIAW 4028	Check varieties				C.D.
				HI 1605	DBW 110	MP 1358	NIAW 3170	
Mean yield (q ha ⁻¹)	2020-21 (NIVT 5B)	07	33.30	28.80	29.60	-	-	2.3
	2021-22 (AVT I)	10	33.60	33.50	-	33.30	33.00	1.3
	2022-23 (AVT II)	07	33.30	33.30	-	-	34.10	1.1
	Mean		33.43	31.86	29.60	33.30	33.55	-
	Weighted mean		33.45	32.07	29.60	33.30	33.45	
Frequency in 1 st non significant group	2020-21 (NIVT 5B)		5/7	3/7	0/7	-	-	
	2021-22 (AVT I)		6/10	4/10	-	6/10	6/10	
	2022-23 (AVT II)		4/7	5/7	-	-	5/7	
	Total		15/24	12/24	0/7	6/10	11/17	

Performance for Agro-morphological traits

The average plant height of the variety is 82 cm, and it found resistant to lodging. The variety reaches physiological maturity in 94-124 days with an average of 106 days. Average thousand grain weight of the NIAW 4028 is 44 g as compare to the check varieties DBW 110

(42 g), MP 1358 (42 g), NIAW 3170 (41 g) and HI 1605 (40 g). NIAW 4028 was tested with checks under different irrigation levels i.e. zero irrigation, one irrigation (at Crown Root Initiation) and two irrigations (at CRI and boot leaf stage). It is found to be irrigation responsive with



increased yield of 12.43 % and 55.39 % with one and two irrigations respectively over zero irrigation.

Disease Resistance

A comprehensive screening of wheat genotypes included in AVTs was conducted in Jashore, Bangladesh, during 2020-21 and 2021-22 growing seasons to identify resistance sources against wheat blast disease. Total 350 entries were screened against blast at two different dates of sowing during 2020-21 and out of that, 283 again tested at two different dates of sowing during 2021-22. Among

the entries screened, NIAW 4028 exhibited notable resistance to wheat blast disease, with an average score of 5.0 compared to susceptible check, which scored 86.0 (Table 2). Additionally, NIAW 4028 showed high level of resistance to leaf and stem rusts with ACI values of 1.6 for both rusts under artificial epiphytotic conditions (Table 3). Gene postulation analysis suggested the presence of a *Sr30+5+2* gene combination conferring stem rust resistance in NIAW 4028. It has demonstrated the resistance to Karnal bunt, Powdery mildew and flag smut.

Table 2: Performance of the NIAW 4028 screened against wheat blast at Jashore, Bangladesh

Wheat Blast Reaction	NIAW 4028		Qualifying entries				Resistant Check		Susceptible Check	
	HI 1665		DBW 359							
	HS	Av	HS	Av	HS	Av	HS	Av	HS	Av
0,0 (Free)	10	5.0	100	83.4	16	9.0	4.5	1.1	100	86.0

(Total 350 entries were screened against blast at Jashore, Bangladesh at two different dates of sowing during 2020-21 and out of that 283 again tested at Jashore, Bangladesh at two different dates of sowing during 2021-22.)

Table 3: Evaluation of NIAW 4028 and checks under artificial epiphytotic conditions

Disease	Year	NIAW 4028		Check varieties					
		HI 1605		MP 1358		NIAW 3170			
		HS	ACI	HS	ACI	HS	ACI	HS	ACI
Leaf Rust	2020-21	15MR	0.9	60S	10.9	40S	6.1	10MS	2.7
	2021-22	20MS	3.2	40S	14.4	20S	4.8	40S	9.6
	2022-23	10MR	0.7	40MS	16.6	-	-	20 MS	6.6
	HS & Mean ACI	20 MS	1.6	60S	14.0	40S	5.5	40S	9.6
Stem Rust	2020-21	10MS	2.6	60S	15.6	30MS	6.0	20S	5.7
	2021-22	10MS	1.2	20MS	3.7	20MS	6.0	20MS	3.5
	2022-23	5S	1.1	30S	7.3	-	-	40S	19.5
	HS & Mean ACI	5S	1.6	30S	8.9	30MS	6.0	40S	9.6
Gene postulation									
Leaf Rust		-		Lr13+		Lr23+10+		Lr13+10+	
Stem Rust		Sr30+5+2+		Sr11+		Sr11+		Sr8a+2+	

HS = Highest score, ACI = Average coefficient of infection

Quality parameters

The quality characteristics of NIAW 4028 were evaluated along with check varieties, it recorded better *chapati* quality score (7.50), good bread loaf volume (507 mL), and higher biscuit spread factor (8.50) than the checks except the check variety NIAW 3170 (10.5). Protein content of the variety NIAW 4028 was 12.43 % with Glu-

1 score (11.1) indicating better protein quality. The other quality parameters of the variety are acceptable as per the prescribed standards (Table 4).

Varietal descriptors

NIAW 4028 has semi-erect growth habit; it flowers in 57 days and matures in 106 days. It has pale green foliage and waxy attributes at the time of ear emergence. The ears



Table 4: Performance of NIAW 4028 along with checks for quality traits

Quality traits	NIAW 4028	Check varieties		
		HI 1605	MP 1358	NIAW 3170
Nutritional quality				
Protein (%)	12.4	12.7	11.80	12.9
Fe (PPM)	39.7	39.5	38.2	39.0
Zn (PPM)	37.0	39.2	31.0	38.6
Phenol test (max 0)	6.5	3.3	-	6.7
Grain Characters				
Grain appearance (Max score 10)	6.3	6.3	6.2	5.7
Hectolitre weight (kg/hl)	79.2	82.1	80.6	78.9
Grain Hardness Index	84.5	89.7	79.4	36.3
Chapati quality characters				
Chapati quality (max score 10)	7.5			
Sedimentation value (ml)	59.0	57.5	49.5	52.4
Dry gluten (%)	11.1	11.1	-	10.5
Wet gluten (%)	33.4	33.1	-	32.6
Gluten index (%)	77.0	74.0	-	61.0
Bread quality characters				
Bread loaf volume (ml)	507	518	-	510
Bread quality (max core 10)	5.8	6.4	-	5.5
Biscuit quality characters				
Biscuit spread factor	8.5	8.0	-	10.5



Field View

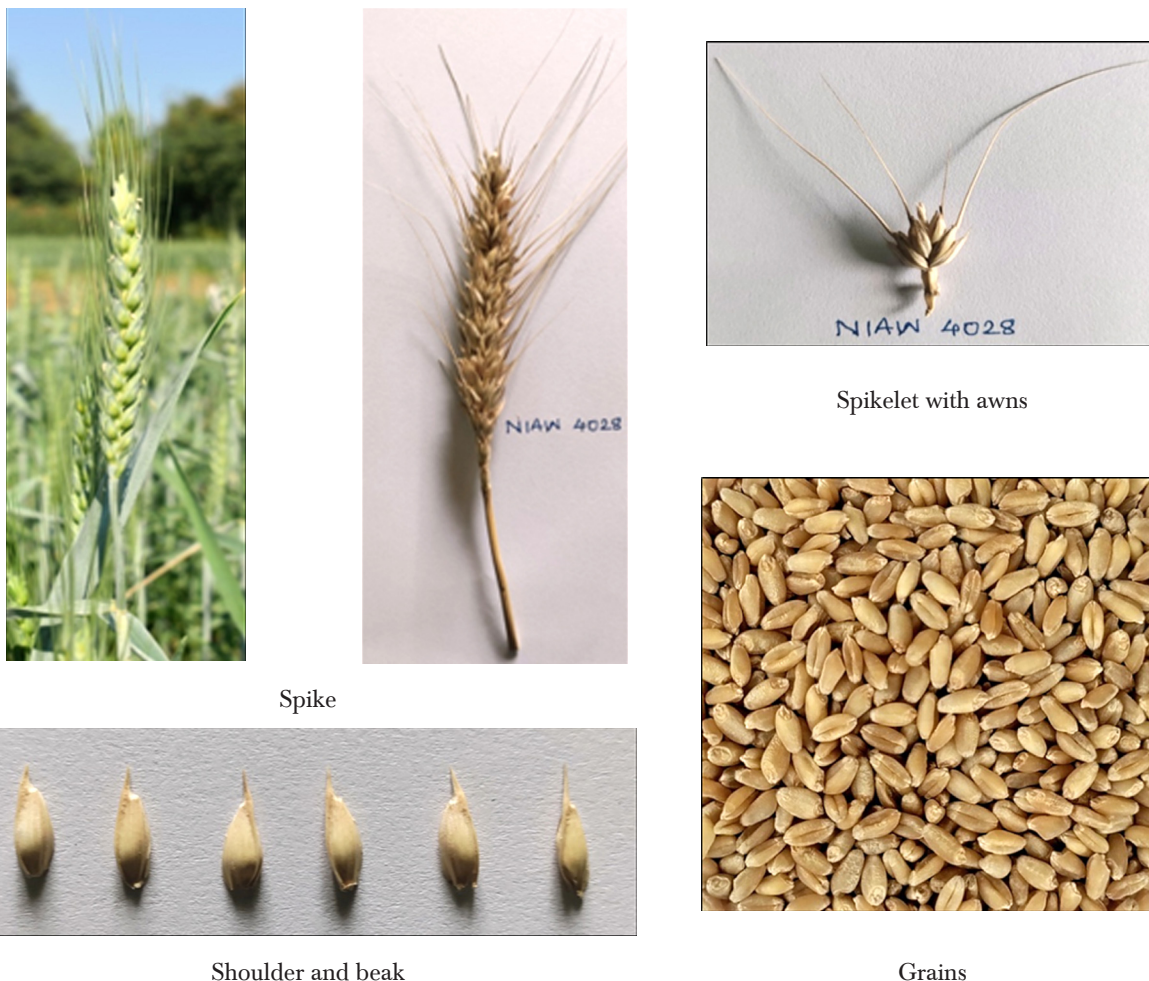


Fig 2: Pictorial presentation of various characters of NIAW 4028

are white in colour, tapering shaped with medium density, having white colored and short awns. The peduncle is having straight attitude and medium length. The glumes have elevated shoulder shape, narrow shoulder width with long beak length. Grains are amber colored, oblong shaped with hard texture having average test weight of 44 g. A pictorial presentation of few characters of the variety is shown in Fig 2.

Notification and seed production

Phule Anurag (NIAW 4028) was released and notified by the Central Sub-Committee on Crop standards, Notification, and Release of Varieties in India *vide* notification number S.O.1560 (E), dated 26th of March, 2024 via official gazette. Agricultural Research Station, Niphad is the maintainer and will be responsible for production of the nucleus and breeder seeds of this variety.

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Author contributions

All authors contributed equally for preparing final version of the manuscript.

Conflict of interest

No

Declaration

The authors declare no conflict of interest.

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